(1) TITLE

PORTABLE ELECTRONIC READING APPARATUS

(2) CROSS-REFERENCE TO RELATED APPLICATIONS

None.

(3) STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

None.

(4) REFERENCE TO AN APPENDIX

The present application includes a hard copy appendix comprising pertinent specification pages and drawings of co-inventors' U.S. Pat. Appl. Ser. No. 09/844,862, by ZHANG et al. for MOLECULAR MECHANICAL DEVICES WITH A BAND GAP CHANGE ACTIVATED BY AN ELECTRIC FIELD FOR OPTICAL SWITCHING APPLICATION (Hewlett-Packard Company, assignee) as relates to subject matter claimed in accordance with the present invention.

(5) BACKGROUND OF THE INVENTION

(5.1) FIELD OF THE INVENTION

[0001] The present invention relates generally to electronic publishing and, more particularly, to portable electronic reading apparatus. More specifically, the present invention relates to an electronic book using bi-modal, bistable molecular imaging technology, sometimes referred to in the art as "nanotechnology."

(5.2) DESCRIPTION OF RELATED ART

[0002] Portable reading material today is made available through books, magazines, newspapers, and various other forms of hard copy using a colorant (e.g., ink

or toner) on paper. Readable informational text and image content (hereinafter simply "content" or "document content") published in these forms is of a sufficiently high resolution and contrast to be read easily over prolonged periods of time without eye discomfort. Such commercial grade high resolution print is over 600 dots per inch. Portability allows individual user preference for comfortable reading in locations of choice. Moreover, body positions may be periodically varied to change reading distance and posture to maintain personal comfort. Generally, such hard copy print media requires high costs in printing, binding, warehousing, and distribution. Since these factors require a relatively lengthy time expenditure between content generation and availability to the reader, the content of the media is often not contemporaneous; even newsprint is in reality yesterday's or last week's news. The cost is normally amortized through a single reading, after which the book or document is physically stored or discarded. Moreover, hard copy is not an environmentally friendly technology, either as to raw materials and print media manufacturing or waste management.

[0003] Computers, on the other hand, provide virtually instantaneous distribution of content through electronic means, such as the Internet, at significantly reduced cost to the reader. (The term "Internet" is used herein as a generic term for a collection of distributed, interconnected networks (ARPANET, DARPANET, World Wide Web, or the like) that are linked together by a set of industry standard protocols (e.g., TCP/IP, HTTP, UDP, and the like) to form a generally global, distributed network. Private and proprietary intranets are also known and are amenable to conforming uses of the present invention.) Computer displays, however, provide far less comfortable reading at significantly lower resolution

when compared to hard copy print media. Cathode ray tube displays have low portability and require substantially stationary body positioning for reading at fixed focal length, leading to comparatively rapid eye strain and posture discomfort. Portable computer liquid crystal displays (LCD) allow somewhat greater portability, but at the expense of display contrast, off-axis viewability, and higher cost. The at least one order of magnitude lower resolution of computer displays in comparison to commercial print media commonly prevents the reader from seeing a full page of the comparable hard copy document at one time. In part, the further cost of lower resolution of portable displays stems from the difficulty of matrix addressing at higher resolution. Normally, the reader must use button controls to scroll the displayed image down the document page to read its contents. When a long document is downloaded, as from the Internet, the reader will commonly print the contents to gain back the aforementioned hard copy print media benefits. Such printing, however, adds local printing cost to the process for documents that are still commonly read once and discarded. Current computer solutions are contrary to the needs of book, magazine and newspaper distribution.

[0004] There is a need for a paradigm shift in the concept of reading media and media distribution and for providing portable electronic apparatus.

[0005] One exemplary solution is the fixed screen electronic book such as shown in U.S. Pat. No. 6,037,954 (Mar. 14, 2000), by McMahon, for a PORTABLE HAND-HELD READING DEVICE. McMahon uses a convention LCD display. The described device is limited both in size, resolution, viewing angle limitations, battery life, and general versatility by inherent limitations of the fixed screen display.

[0006] Another exemplary solution is the PORTABLE ELECTRONIC APPARATUS proposed by Phillipps in U.S. Pat. No. 6,107,988 (Aug. 22, 2000) for a folded display, hinged to be opened and closed in the manner of a book. This solution requires two LCD displays In addition to the limitations as mentioned with respect to the McMahon patented device, the Phillipps apparatus would have a relatively heavy power demand to support the double LCD display requirements.

[0007] A third exemplary solution is proposed by Jacobson in U.S. Pat. No. 6,124,851 (Sep 26, 2000) for an ELECTRONIC BOOK WITH MULTIPLE PAGE DISPLAYS. Jacobson has multiple page displays formed on flexible, thin substrates which use E-Ink Corporation's (assignee) microcapsule electronic ink (Figures 7A-7D therein) for typesetting each page, maintaining a "natural haptic and visual interface of...normal paper books."

[0008] Moreover, with the paradigm shift as described, accessibility to electronic document service providers and document retrieval requires end-user devices having greater and easier accessibility to the content. Therefore, there is a need for a direct interface between the portable electronic reading apparatus and the content provider.

[0009] There is a need for an electronic reading apparatus solution providing a high resolution, high contrast, compact, portable, electronic book, exceeding the convenience of commercial print media and having a content access capability providing substantially instantaneous download capability.

(6) BRIEF SUMMARY OF THE INVENTION

[0010] In its basic aspect, the present invention provides an electronic book device

comprising: a rewritable viewing screen; and an electrical printhead for writing picture elements of said viewing screen, wherein said viewing screen has a rewritable electronic colorant for printing document content therewith.

[0011] In another aspect, the present invention provides a rewritable digital book device comprising: a housing means for housing components of said device; means for downloading, storing, sequencing, and erasably printing document content; and viewing means for sequentially, erasably writing said content at a commercial grade high resolution hard copy pixel resolution.

[0012] In still another aspect, the present invention provides a method of providing readable pages comprising: downloading data representative of each of said readable pages into a memory; providing a viewing screen having an electric field addressable rewritable colorant thereon; and writing each of said pages sequentially to the viewing screen by passing the screen adjacently across a printhead having electrical fields associated with pixels of the screen such that said data is transferred from said memory to said screen.

[0013] Another aspect of the present invention is a method of doing business of distribution of a document comprising: transmitting electronic data representative of said document; and providing a customer with mechanisms associated with said transmitting for said customer to receive said data on a portable reading device having a single display screen including an electric field addressable rewritable colorant displaying said data in a form substantially identical to a hard copy form of said document.

[0014] The foregoing summary is not intended to be an inclusive list of all aspects,

objects, advantages, and features of the present invention nor should any limitation on the scope of the invention be implied therefrom. This Summary is provided in accordance with the mandate of 37 C.F.R. 1.73 and M.P.E.P. 608.01(d) merely to apprise the public, and more especially those interested in the particular art to which the invention relates, of the nature of the invention in order to be of assistance in aiding ready understanding of the patent in future searches. Objects, features and advantages of the present invention will become apparent upon consideration of the following explanation and the accompanying drawings, in which like reference designations represent like features throughout the drawings.

(7) BRIEF DESCRIPTION OF THE DRAWINGS

[0015] In accordance with 37 C.F.R. 1.84(u), in order to prevent confusion with drawings of the Appendix hereto, the drawings of this application use double capital letter suffices.

[0016] FIGURE 1AA is a schematic illustration of the present invention.

[0017] FIGURE 1BB is a schematic illustration of an alternative embodiment of the present invention as shown in FIGURE 1AA.

[0018] FIGURE 2AA is a simplified, schematic block diagram of the present invention as shown in FIGURES 1AA and 1BB.

[0019] FIGURES 3AA and 3BB are sequential illustrations of the retraction-extraction steps of use of the present invention as shown in FIGURE 1AA.

[0020] FIGURE 4AA is an exemplary printhead electrode in accordance with the present invention as shown in FIGURE 2AA.

[0021] FIGURE 4BB is an exemplary printhead electrode in an alternative embodiment to FIGURE 4AA and in accordance with the present invention as shown in FIGURE 2AA.

[0022] FIGURE 5AA is a schematic illustration of an alternative embodiment of the present invention depicting an alternative implementation to the implementation of FIGURES 1AA and 1BB.

[0023] FIGURE 6AA is a schematic illustration of another alternative embodiment of the present invention depicting an alternative implementation to the implementation of FIGURES 1AA and 1BB.

[0024] FIGURE 7AA is a block diagram illustration for a method and apparatus for doing business over the internet in accordance with the present invention.

[0025] The drawings referred to in this specification should be understood as not being drawn to scale except if specifically annotated.

(8) DETAILED DESCRIPTION OF THE INVENTION

[0026] Reference is made now in detail to a specific embodiment of the present invention, which illustrates the best mode presently contemplated by the inventors for practicing the invention. Alternative embodiments are also briefly described as applicable.

DEFINITIONS

[0027] The following terms and ideas are applicable to both the present discussion and the Appendix hereto.

[0028] The term "self-assembled" as used herein refers to a system that naturally adopts some geometric pattern because of the identity of the components of the system;

the system achieves at least a local minimum in its energy by adopting this configuration.

[0029] The term "singly configurable" means that a switch can change its state only once via an irreversible process such as an oxidation or reduction reaction; such a switch can be the basis of a programmable read-only memory (PROM), for example.

[0030] The term "reconfigurable" means that a switch can change its state multiple times via a reversible process such as an oxidation or reduction; in other words, the switch can be opened and closed multiple times, such as the memory bits in a random access memory (RAM) or a color pixel in a display.

[0031] The term "bistable" as applied to a molecule means a molecule having two relatively low energy states (local minima) separated by an energy (or activation) barrier. The molecule may be either irreversibly switched from one state to the other (singly configurable) or reversibly switched from one state to the other (reconfigurable). The term "multi-stable" refers to a molecule with more than two such low energy states, or local minima.

[0032] The term "bi-modal" for colorant molecules in accordance with the present invention may be designed to include the case of no or low activation barrier for fast but volatile switching. In this latter situation, bistability is not required, and the molecule is switched into one state by the electric field and relaxes back into its original state upon removal of the field; such molecules are referred to as "bi-modal". In effect, these forms of the bi-modal colorant molecules are "self-erasing". In contrast, in bistable colorant molecules the colorant molecule remains latched in its state upon removal of the field (non-volatile switch), and the presence of the activation barrier in that case requires

application of an opposite field to switch the molecule back to its previous state. Also, "molecular colorant" as used hereinafter as one term to describe aspects of the present invention is to be distinguished from other chemical formulations, such as dyes, which act on a molecular level; in other words, "molecular colorant" used hereinafter signifies that the colorant molecules as described in the Appendix and their equivalents are employed in accordance with the present invention.

[0033] Micron-scale dimensions refers to dimensions that range from 1 micrometer to a few micrometers in size.

[0034] Sub-micron scale dimensions refers to dimensions that range from 1 micrometer down to 0.05 micrometers.

[0035] Nanometer scale dimensions refers to dimensions that range from 0.1 nanometers to 50 nanometers (0.05 micrometers).

[0036] Micron-scale and submicron-scale wires refers to rod or ribbon-shaped conductors or semiconductors with widths or diameters having the dimensions of 0.05 to 10 micrometers, heights that can range from a few tens of nanometers to a micrometer, and lengths of several micrometers and longer.

[0037] "HOMO" is the common chemical acronym for "highest occupied molecular orbital", while "LUMO" is the common chemical acronym for "lowest unoccupied molecular orbital". HOMOs and LUMOs are responsible for electronic conduction in molecules and the energy difference between the HOMO and LUMO and other energetically nearby molecular orbitals is responsible for the color of the molecule.

[0038] An "optical switch," in the context of the present invention, involves changes

in the electro-magnetic properties of the molecules, both within and outside that detectable by the human eye, e.g., ranging from the far infra-red (IR) to deep ultraviolet (UV). Optical switching includes changes in properties such as absorption, reflection, refraction, diffraction, and diffuse scattering of electro-magnetic radiation.

[0039] The term "transparency" is defined within the visible spectrum to mean that optically, light passing through the colorant is not impeded or altered except in the region in which the colorant spectrally absorbs. For example, if the molecular colorant does not absorb in the visible spectrum, then the colorant will appear to have water clear transparency.

[0040] The term "omni-ambient illumination viewability" is defined herein as the viewability under any ambient illumination condition to which the eye is responsive.

[0041] As a general proposition, "media" in the context of the present invention includes any surface, whether portable or fixed, that contains or is layered with a molecular colorant or a coating containing molecular colorant in accordance with the present invention wherein "bistable" molecules are employed; for example, both a flexible sheet exhibiting all the characteristics of a piece of paper and a writable surface of an appliance (be it a refrigerator door or a computing appliance using the molecular colorant). "Display" (or "screen") in the context of the present invention includes any apparatus that employs "bi-modal" molecules, but not necessarily bistable molecules. Because of the blurred line regarding where media type devices ends and display mechanisms begin, no limitation on the scope of the invention is intended nor should be implied from a designation of any particular embodiment as a "media" or as a "display."

[0042] As will become apparent from reading the Detailed Description and Appendix, "molecule" can be interpreted in accordance with the present invention to mean a solitary molecular device, e.g., an optical switch, or, depending on the context, may be a vast array of molecular-level devices, e.g., an array of individually addressable, pixel-sized, optical switches, which are in fact linked covalently as a single molecule in a self-assembling implementation. Thus, it can be recognized that some molecular systems comprise a super-molecule where selective domain changes of individual molecular devices forming the system are available. The term "molecular system" as used herein refers to both solitary molecular devices used systematically, such as in a regular array pixel pattern, and molecularly linked individual devices. No limitation on the scope of the invention is intended by interchangeably using these terms nor should any be implied.

GENERAL DESCRIPTION

[0043] Turning to **FIGURE 1AA**, the present invention in general introduces a portable, electronic, apparatus for displaying reading material, referred to hereinafter as an "e-book" 100, having an interface and appropriate on-board circuitry and programming to allow direct download of content from a provider. FIGURE 1AA schematically illustrates a pocket-sized implementation, namely, similar in a height dimension to a paperback book, about six to seven inches. As will be explained in further detail, the e-book's "binding," or spine, 103 need only be an inch or more in cross-section, and may possibly be reduced to make the e-book 100 not much larger than a writing pen.

[0044] FIGURE 1BB is an alternative embodiment of an e-book 100 in according with the present invention as shown in FIGURE 1AA, being larger sized and more

amenable to being carried in a briefcase, but thereby providing a much larger viewing area, e.g., comparable to a writing tablet size, hard copy magazine page, or the like.

[0045] Looking to **FIGURE 2AA**, the e-book 100 of the present invention includes a rewritable screen 105, an electrode array printing device 113, a media translation sensor 118, a reversible, biased, sheet payout device 106, and associated circuitry 107, 109, 111, 119, 125 to download, store, sequence, and erasably print on the screen text and image data. The e-book 100 has, preferably, a single, rewritable, viewing screen 105, using electronic colorant imaging technology. While the screen 105 could have a fixed geometry and orientation as known in the electronic book state of the art, as illustrated and later described with respect to FIGURES 1AA, 2AA, 3AA-3CC, and 5AA the preferred embodiment of the present invention includes a screen 105 that is retractable. In a very compact implementation, the e-book 500 is reduced to a pen-sized appliance 501 as illustrated in **FIGURE 5AA** having a retractable screen 503. **FIGURE 6AA** demonstrates an insertable and removable hard-card screen 603. Because of the nature of the screen 105 writing and erasing technology employed, it is an advantage of the present invention that only a single screen 105 is required.

[0046] The image and text content on the screen 105 is produced using an electronic colorant. Two commercially available technologies adaptable to implementations of the present invention are (1) the microcapsule electronic ink technology available from E-Ink Corporation and described by Jacobson, supra, incorporated herein by reference; and (2) the Xeroxtm Gyricontm microsphere technology available from Xerox Corporation as shown in U.S. Pat. No. 5,604,027 (Sheridon),

incorporated herein by reference. Note that by definition, such an electronic colorant is substantively distinguished from current video screen technology that uses e.g., electron gun stimulated coatings, liquid crystals or the like, active transistors or diode elements, or other such devices, and by there very nature are not analogous thereto.

[0047] However, in the preferred and improved viewability embodiments over these two technologies, the rewritable viewing screen 105 uses a molecular colorant technology. The fundamentals of this field writeable and erasable, bi-modal and bistable molecular colorant technology are described in full in the common assignee's U.S. Pat. Appl. Ser. No. 09/844,862, filed on April 27, 2001, by Zhang et al., for a MOLECULAR MECHANICAL DEVICES WITH A BAND GAP CHANGE ACTIVATED BY AN ELECTRIC FIELD FOR OPTICAL SWITCHING APPLICATIONS; the Appendix of this application is a copy of appropriate specification pages and drawings thereof as relates to the present invention.

[0048] FIGURE 2AA is a schematic block diagram of the e-book 100 apparatus in accordance with the present invention. A microprocessor-based controller 111 is provided and incorporated into the spine 103 for data management. The contents of a page, or pages, a book, or books, may be digitally downloaded through an input port 107 into a memory 109 housed in the book spine 103 via a conventional computer link or Internet access device (wired or wireless). Both contemporaneous page-by-page download - such as when actively connected to the World Wide Web - or complete download of the document into on-board memory 109 are available in accordance with the present invention. State-of-the-art computing handshake protocols are employed to ensure user

identification, form of payment, copyright protection, and the like as is common to current Internet access and product purchase. Further details of such download apparatus and methodology are described hereinafter with respect to FIGURE 7AA.

[0049] With the onset of the Internet age, end users are generally sophisticated computer device users and insistent upon both rapid and convenient data access. Though shown generically, it is preferred that the input port 107 be a state-of-the-art wireless radiowave or lightwave (including infrared) communications port. An employable method and apparatus for a public access system is described in detail in U.S. Pat. App. Ser. No. 09/685642 by Cohen, filed Oct. 10, 2000 (assigned to the common assignee herein and incorporated herein by reference) for PAY PER USE DIGITAL PHOTOGRAPHY, where public kiosk-type access for printing or transmitting digital photographs within a context boundary is described. Application of such a concept can be adapted for the present invention. For example, an airport terminal may supplement, or supplant a book store, with a kiosk for downloading written materials; indeed, with an appropriate on-board interface, such may be downloadable while in flight. It is also expressly considered that state of the art communication from the e-book to the publisher or other content provider such as by microwave communication, direct satellite up-links, and the like, can be employed. An object of the present invention is the ability to obtain any document, anytime, anyplace where some form of communications link can be established.

[0050] Alternatively, the spine 103 can be adapted to accommodate a state-of-the-art plug-in memory device (not shown). In a specific implementation such as shown in

FIGURE 1AA, size is optimized; in FIGURE 1BB, more amenable to such plug-in memory devices, the specific implementation is also more concerned with providing a larger viewing screen at the cost to portability.

[0051] In operation, each document page is sequentially printed from memory 109 through a high resolution electrode array printhead 113. A variety of specific electrodes are fully described in the common assignee's U.S. Pat. Appl. Ser. No. __/___,___ filed by common inventor Vincent (docket no. 10005743); a description is included hereinafter with respect to FIGURE 4AA.

[0052] The viewing screen 105 is bias mounted, e.g., on a spring-loaded (represented by the double-headed arrows) cylinder 106, and pulled out of the spine 103 and retracted into the spine through a slot 115 in a manner as demonstrated in sequence by **FIGURES 3AA** and **3BB**. The microprocessor-based controller 111 can be pre-programmed for a simple download and sequential page turning operation, or an optional user control panel 117 can be provided on the spine 103, allowing user versatility. For example as demonstrated by FIGURES 3AA and 3BB, a first page of data from the Wall Street Journal newspaper is downloaded from the memory 109, transferred in a known manner data buffering operation to the printhead 113, and written as a current page while the screen 105 is being extracted from the spine 103, i.e., writing the current page during the position shift of the screen 105 from FIGURE 3AA to FIGURE 3BB. Cache memory (not shown) and associated data storage and buffering techniques can be provided for the controller 111.

[0053] Referring also to FIGURE 3AA, screen support rollers 301, 302, 303 can be

provided as needed for any specific implementation. Note also that one of the rollers can optionally also be an electrode apparatus or a position encoder. Once it is sensed that the screen 105 is fully extracted, a subsequent page is buffered for downloading from memory 109 to the printhead 113. Once the current page is read, the contents of a subsequent page is printed by allowing retraction of the screen 105 under the spring force back into the spine 103 (from FIGURE 3BB position to FIGURE 3AA position), which is sensed by the controller 111. As the screen 105 is extracted through the slot 115 a second time (FIGURE 3AA position to FIGURE 3BB position), the current page data is erased and the screen is reprinted with the new image data, the subsequent page. As the screen 105 has a bistable molecular colorant for imaging, as described hereinafter and in the Appendix, the erasing and rewriting can be simultaneous. Writing and erasing my be done during either the extraction or retraction motion of the screen, or both. Note that this motion is much like the motion of turning a hard copy book page.

[0054] Control buttons 119 on the spine 103 allow forward, "F," and reverse, "R," movement through the document, skipping to adjacent chapters and moving from one document to another, and the like. Note that in a sophisticated embodiment, controls can be provided for word and topic search functionality, such as by connecting a computer with keyboard to the controller 111 via the input port 107, or as demonstrated by FIGURE 6AA by the provision of a menu and control function screen 605 on-board.

[0055] Once a reading session is completed, e.g., the reader is finished with the present page(s) on the screen 105, the screen is allowed to retract into the spine 103 to provide compact storage of the e-book 100. It thereby requires less storage space than

the hard copy book(s) it replaces. Note that while the last page read is stored in memory 109, the last read page can be electronically retained on-screen, "book marked," via the bistable nature of the screen 105 without the need for a separate operation (e.g., in the nature of a virtual pointer as would be used in the prior art). A conventional pull tab or electronic feed (neither shown) can be provided in a known manner for facilitating extraction-retraction operations. An appliance operational menu(s) for using the control buttons may be displayed on the screen 105 or on a separate display (e.g., associated with the spine 103 or as shown in FIGURE 6AA).

DESCRIPTION OF SPECIFIC EMBODIMENTS

[0056] The rewritable viewing screen 105 consists of a flexible substrate that has a viewing area using an electronic colorant thereon, preferably employing the bistable, bi-modal molecular colorant. The full details of specific rewritable mechanisms suited to adaptation to the present invention are set forth in co-inventor Vincent's U.S. Pat. Appl. Ser. No. 09/919,394, filed July 31, 2001 by Vincent et al. for a FIELD ADDRESSABLE REWRITABLE MEDIA (assigned to the common assignee and incorporated by reference in its entirety); the molecular colorant used for forming text and images is described in pertinent part in the Appendix hereto. For the main part, in order to be durable, the substrate of the screen 105 should be fabricated of a flexible, durable, material, such as of polymer-coated sheets of material selected from the group including at least flexible plastic, plasticized-paper compounds, or the like. The screen 105 itself in a preferred embodiment is a single sheet of the substrate having an associated layer or incorporation of the bistable, bi-modal molecular colorant described in detail in the Appendix hereto.

[0057] For the present invention, the molecular colorant has such molecules that are preferably black in a conjugated orientation and transparent in a less conjugated orientation. By making the screen substrate white, the rewritable screen 105 produces high contrast black and white images. The colorant may comprise a single field switchable black-transparent molecular system or multiple color molecular systems that collectively produce a composite black and includes full color imaging, providing a substantial improvement to the state of the art. By using bi-modal molecular colorant, the resolution of the produced image is limited only by the electric field resolution produced by the electrode array printhead 113 elements (see following details regarding FIGURE 4AA). In other words, the picture elements, or "pixels," of the screen can be of a resolution of much smaller dimensions than achieved by particulates such as ink droplets (where commercial resolution is 1200 drops per inch) or controlled microcapsules (e.g., the Xerox bichromal balls or E-Ink Corporation's electronic ink). Depending upon the specific implementation, a pixel addressed by a printhead electrode may contain millions of bi-modal molecules in accordance with the present invention, rendering the notion of "resolution" an individual pixel meaningless. Specifically, to create a seamless set of pixels which render the conventional notion of resolution meaningless, an exemplary, molecular wire adaptable for printing pixels is described by Kuekes et al. in U.S. Pat. No. 6,128,214 for a MOLECULAR WIRE CROSSBAR MEMORY (assigned to the common assignee herein and incorporated herein by reference) and may be employed in accordance with the present invention for the printhead mechanism 113, particularly useful for full page printing in an embodiment such as that of FIGURE 6AA. Moreover,

the molecular colorant additionally has virtually instantaneous switching speed, beneficial to the needs of fast pagination. The colorant is preferably contained in a polymeric layer that may be optionally overcoated with a transparent protective or gloss control coating layer.

[0058] The viewing screen 105 may optionally contain a mosaic pixel pattern of different primary color colorants (e.g., red, green, blue or cyan, magenta, yellow). Such a pattern may be initially imaged onto the screen 105 through conventional printing means, for example, ink jet or lithography. The patterned colorants may be printed optionally with a fiducial mark to allow correct sensing of the colorant positions during electronic imaging. Microprocessor programming for full color displays may be provided. The pattern of colorants of each pixel may then be addressed by the printhead 113 electrode array to produce color images.

[0059] The printhead 113 comprises a sheet-wide linear array, or equivalent staggered array, of electrodes in contact or near contact with the screen 105 surface. Electrode arrays and drive electronics are common to electrostatic printers and their constructions and interfaces are well known. Each electrode 401 is sized, positioned, and electrically addressed in a known manner to provide an appropriate electric field to the colorant layer 405 at each given pixel location (or superset of pixels) along a pixel column (or columns if a staggered array) of the rewritable screen 105.

[0060] Exemplary "fringe field" electrodes are depicted in **FIGURES 4AA** and **4BB**. The electrical field may be oriented perpendicular to the plane of the screen 105 or parallel to it. In the exemplary embodiment of FIGURE 4AA, a common electrode, or

electrodes, 401 is placed adjacent to the screen 105 pixel array so that printing is accomplished by passage of fringe fields through the colorant. Fringe field imaging is advantageous since the electric field is not significantly influenced by the physical structure of the substrate. The fringe field - illustrated by dashed-lines labeled "V_{high}" and "V_{low}". In the embodiment of FIGURE 4AA, the field is concentrated under the electrode tip and the return field is dispersed and therefor does not effect the colorant 405 layer. As shown in FIGURE 4BB, high and low voltage electrodes are used when the roller 303 is not biased. Returning to FIGURE 3AA, a set of rollers 302, 303 may be used to maintain the desired spacing of screen 105 and printhead 113 electrode array. Only a linear array of electrodes 401 is required as each addressable pixel of the screen 105 passes by the printhead 113 during each retraction-extension cycle. Using standard semiconductor wafer, thin film processing to fabricate printhead elements, the packing density of the electrode array can be very great and produce a resolution far exceeding the human visual capability to discriminate individual dots of a dot matrix.

[0061] One end of the rewritable screen 105 is attached to the spring-loaded payout cylinder 106. The spring mechanism 121 of the cylinder 106 can be similar, if not identical, to a common window shade cylinder device. When the e-book 100 is not in use, the screen 105 is retracted by a bias force to wrap around the cylinder 106. As the screen 105 is extracted, the spring mechanism 121 coils. As with the window shade mechanism, the cylinder 106 may optionally contain a ratchet or detent mechanism (not shown) that holds the screen 105 in its extended, "read," position. To retract the screen 105, the user simply pulls the sheet to release the hold. Preferably, the unattached end of the screen

105 has a small attached stop 123, e.g., a bar or rod, that prevents the sheet from retracting into the spine 103 beyond an easily accessed pull point. The payout cylinder 106 may optionally contain, or be axially attached to, a small electric generator (not shown) that produces regenerative current for power supply 125 batteries or that provides or compliments the energy required to print the screen 105 as it is pulled out of the spine 103.

[0062] A known manner media translation sensor 118 is used to sense the instantaneous pixel row location of the screen 105 relative to the electrode array 113 to time printing pulses. This allows the user to extract the screen 105 at virtually any speed. The sensor 118 may also be used to detect the start and end positions of screen 105 travel. A number of different sensing schemes are applicable, including a shaft encoder attached to the axis of the wrap cylinder 106, or support roller 303, FIGURE 3AA, engaged with the screen 105, a screen texture sensor (such as described in co-assigned U.S. Pat. No. 5,089,712), or a linear encoder positioned to read a coding track printed along the screen itself. The rewritable screen 105 is imaged by printing all pixel rows simultaneously, one or more columns of pixels at a time as the sheet is passed by the electrode array 113.

[0063] FIGURE 6AA is an alternative embodiment of an e-book 600 having a conventional hard shell case, or housing, 601. A removable hard viewing screen 603 is provided, being written and erased in the same manner as the previously described embodiments. The housing 601 incorporates a menu screen 605 and a set of control buttons 607. Note that the menu screen 605 may incorporate the same molecular

colorant technology in accordance with the present invention. Note that the control buttons 607 can be replaced with virtual buttons on the menu screen 605, providing greater flexibility. One advantage of this embodiment is that the screen 603, using a bistable molecular colorant can be held in the hand and manipulated with the same haptic convenience of a page of hard copy and the remainder of the apparatus 600 optionally can be left aside. Moreover, this embodiment is adaptable to the use of a complete personal digital assistant ("PDA") apparatus as the electronics and communication package associated with the hard-card screen 603. Thus, data input, storage, sequencing, and printing electronics for the electronic book 100 can be conventional to known manner computer related electronics.

[0064] In general, again referring to FIGURE 2AA, data may be input using standard ROM or RAM cards (e.g., multi-megabyte PCMCIA cards or equivalent format disk drives) that contain the preloaded contents of a book, library of books, magazine, newspaper, or other document or documents. The data may optionally be downloaded into on-board memory 109 via wireless communications or cable or cableless (e.g., infrared) interface from a computer or computer peripheral device. Such downloading may be done by first passing a security code from the electronic book 100 to the document provider server to assure the safety of copyrighted material. The electronic book 100 preferably contains a standardized formatting instruction set to allow fast data transfer into the memory 109 with low document memory requirement; data compression techniques may be employed. When multiple documents are stored in the memory 109, the user selects from a printed list, or table of contents, on the screen 105, the

downloaded document of choice, or simply starts printing pages to be read, by entering or toggling using the control buttons 119 located on the spine 103. Optionally, the spine 103 also can have a small, low power LCD or the like (not shown) to assist in the selection. Extracting the screen 105 prints the first selection. Once printed, the page sequencing electronics of the controller 111 automatically paginates to the next page whenever the screen 105 is retracted and extracted. This sequence may be overridden through key input along the spine controls 117 of the electronic book. Separate buttons or screen selections, for CONTENTS, PAGE, FORWARD and BACKWARD and the like to assist in the process can be provided. Provision can be made for multiple book marked pages to be automatically stored in memory 109 for each stored document so that a reader may return automatically to the last read page when re-selecting a document.

GENERAL COMMENTS, OPERATIONS, AND A METHOD OF DOING BUSINESS

[0065] The present invention provides the high resolution, contrast, portability and compactness of commercial print media, at the distribution speed and cost advantage of Internet distributed media. Using these benefits, books, magazines, newspapers, and journals may be purchased on-line and downloaded via the Internet, replacing the necessity of purchasing the hard copy version. The electronic book may be used in place of standard computer displays for easier on-line reading. It provides superior pixel resolution with far simpler pixel addressing than common to flat panel displays. The bi-stable, rewritable, bi-modal molecular colorants employed are highly energy efficient, requiring energy only to change an image, not to hold it or illuminate it. This is in stark contrast to all computer displays and offers the potential of battery-operated, full

portability. Unlike commercial flat panel displays, the present rewritable page contains a colored film analogous to printed ink films and is thereby readable at all viewing angles, under all ambient lighting conditions which might normally be encountered for book reading. The electronic book of this invention is ideally suited for e-commerce subscription with copyright security.

[0066] Internet, or the like, document providers may download documents to a subscriber via the Internet following a handshake between the connected electronic book and document server. Through the handshake, the book serial number or other security code sequence is passed to the server to assure that the document will be transferred only to the memory of the electronic book. In this instance, the electronic book is a read-only device incapable of passing the copyrighted document contents to other electronic devices. Since the majority of commercial book cost covers the cost of printing, binding, distributing and retail, e-commerce subscription can offer a significant cost savings to the customer while the content provider can receive even greater royalty for the content than through book publication. Automatic billing and payment for document downloading can be implemented by use of the e-book itself where the subscriber and provider have set up an appropriate accounting process or a document order-by-order payment can be implemented where the user uses another mechanism, e.g., a telephone call to the electronic document distributer, to order a specific document.

[0067] **FIGURE 7AA** illustrates apparatus and methodology for a practical implementation of the present invention and a method of doing business. As illustrated by FIGURE 7AA, wireless transceiver communication over the Internet (represented by cloud

symbol 701) to, and document retrieval from, document content service provider(s) 703 is facilitated and greatly enhanced by the use of the technology in accordance with the present invention. The ability to find, select, obtain for a greatly reduced cost, and read a hard copy print quality display of any document on the internet, anywhere, anytime, on a fully portable appliance advances the state of the art significantly.

[0068] In general, the service "PROVIDER" 703 is an Internet or intranet accessible, computer server 705, having a wireless transceiver ("SERVER XCVR") interface 707. A client browser accessible WEB SITE 709 includes all of the communications programs for browsing, selecting, paying for, and downloading selected content, e.g., a novel.

[0069] A generically represented e-book 200 is provided with an on-board electronics package 715 (exploded, magnified, and represented as "on-board" the appliance 711 by dashed-arrow 713). Application specific integrated circuits ("ASIC") may be employed in implementing functions and programming associated with the invention. Included in the e-book 200 is an adapted implementation of the display screen 700 in accordance with the present invention.

[0070] The e-book 200 electronics package 715 includes a transceiver, "CLIENT XCVR," 717 adapted for communicating over the Internet 701 in a known manner. A BROWSER program 719 is provided for interactively communicating with the SERVER 705 web site 709. When the user of the e-book 200, the CLIENT, finds and purchases document content of interest, the content from the WEB SITE 709 is downloaded into the appliance memory 721 (it is known in the art to use data compression to limit the needed memory capacity to a reasonable size). Automatic downloads via subscription services for

documents like daily newspapers (see FIGURE 2AA) can be programmed. From memory, the CLIENT uses controls 201 to transfer pages of the document to the screen display 700.

[0071] Alternatively, or in addition to the wireless transceiver 717 interface, the telecommunications e-book 200 may include cable type interconnections for accessing the Internet 701.

[0072] In operation, as sent by the PROVIDER 703 from the WEB SITE 709, a first extracted page from the memory 721 transferred onto the display 700 will initially show in progressive order a menu, or index, of available document services, document categories, and document titles (and preferably an abstract of the content). The CLIENT can then use the BROWSER 719 as an interface. The CLIENT can place an order in real time, paying the invoiced amount - e.g., via a charge card or other credit information related data exchange with the PROVIDER 703, such as by having an account related to the e-book 200 serial number (analogous to a long distance telephone call) - and downloading the document immediately or at a later, convenient time. An attractive commercial implementation is for the PROVIDER 703 to offer any CLIENT the ability to obtain otherwise subscription documents such as newspapers, magazines, and the like, on a pay-per-view, non-subscription basis at a low cost as hard copy printing and mailing costs are eliminated. In placing an order, the display 700 is used to show ordering information, menus, lists, virtual shopping cart contents, and the like, provided by the from the SERVER 705 over the internet 701.

[0073] The foregoing description of the preferred embodiment of the present

invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form or to exemplary embodiments disclosed. Obviously, many modifications and variations will be apparent to practitioners skilled in this art. Similarly, any process steps described might be interchangeable with other steps in order to achieve the same result. The embodiment was chosen and described in order to best explain the principles of the invention and its best mode practical application, thereby to enable others skilled in the art to understand the invention for various embodiments and with various modifications as are suited to the particular use or implementation contemplated. It is intended that the scope of the invention be defined by the claims appended hereto and their equivalents. Reference to an element in the singular is not intended to mean "one and only one" unless explicitly so stated, but rather means "one or more." Moreover, no element, component, nor method step in the present disclosure is intended to be dedicated to the public regardless of whether the element, component, or method step is explicitly recited in the following claims. No claim element herein is to be construed under the provisions of 35 U.S.C. Sec. 112, sixth paragraph, unless the element is expressly recited using the phrase "means for. . ." and no process step herein is to be construed under those provisions unless the step or steps are expressly recited using the phrase "comprising the step(s) of. . .." What is claimed is: